

The Method of Drawing Crease Pattern of Kamiya Pattern and Its Variations

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Abstract

We propose the method of drawing a certain kind of crease pattern such as it in Figure 1, 3. This is a way to focus on special creases and gives us a new point of view in origami design.

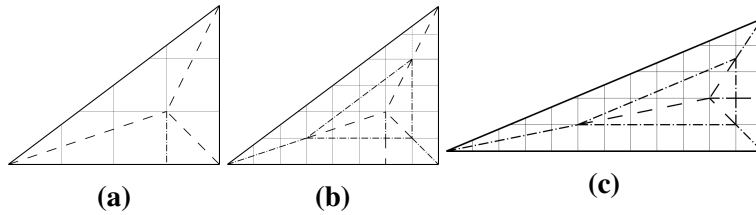


Figure 1: Kamiya patterns.

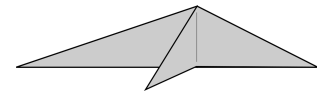


Figure 2:
Folded model of 1a.

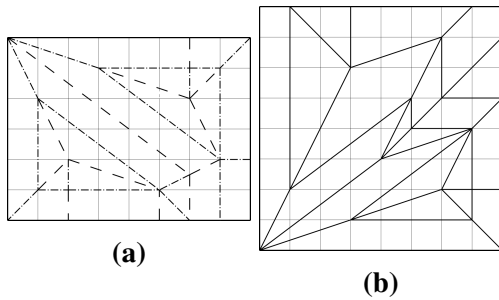


Figure 3: Variations of Kamiya pattern.

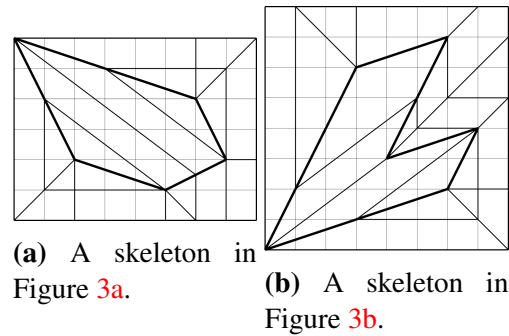


Figure 4: Skeletons in Figure 3.

The crease patterns in Figure 1 is called “Kamiya pattern” that are obtained by folding Pythagorean triangles. They are discovered by Satoshi Kamiya in 1997. Kota Imai discovered many variations of Kamiya pattern, such as the crease pattern in Figure 3a, from 2013. These crease structures are useful for designing complex origami works. For example, we can design an insect which has spiny legs by using these crease patterns.

In this research, we will treat some crease patterns so that the creases in question are assigned to neither mountain creases nor valley creases. Further they are locally flat, foldable at a neigh-

borhood of any vertex and the creases meets horizontal line at angles within the set

$$U := \left\{ \theta + \frac{n\pi}{2} \mid \theta = 0, \pm \arctan 2, \pm \arctan 3, \pm \arctan \frac{3}{4}, \pm \arctan 7, n \in \mathbb{Z} \right\}.$$

The angles appeared in Figure 1a, 1b, 3 are in U . Although some angles appeared in Figure 1c are not in U , we do not treat these angles for simplicity.

Proposition 1. *Let $S := \{ \pm \arctan 2 + \frac{n\pi}{2}, \pm \arctan 3 + \frac{n\pi}{2} \mid n \in \mathbb{Z} \} \subset U$. In crease patterns which agree with our setting, creases which meet horizontal line at angles in S compose closed contours. Here we regard a contour as a closed contour if it is disconnected at a cut line of paper.*

We use this property to draw some crease patterns.

Motivated by Proposition 1, we define a special class of creases.

Definition 2. *A closed contour in a crease pattern is a **skeleton** if it is composed of creases which meet horizontal line at angles in S .*

For example, skeletons in Figure 3 are shown in Figure 4.

We can draw crease patterns using skeletons. Our main result is the following:

Main Result. *Our crease patterns can be drew by combining the following ways:*

1. *Draw skeletons.*
2. *Draw creases from vertices of skeletons to make them locally flat foldable.*
3. *Draw creases to make all vertices locally flat foldable.*

For example, this process is carried out such as in Figure 5.

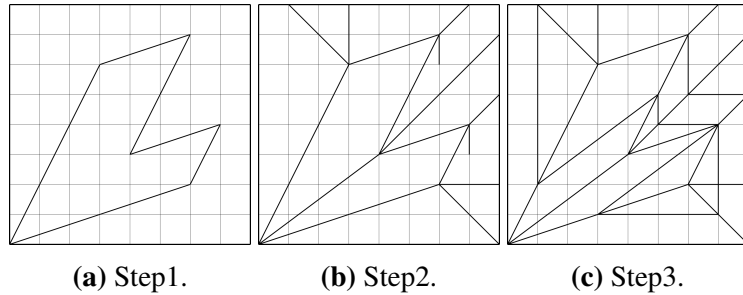


Figure 5: Examples for drawing crease pattern by a skeleton.

References

Yuya Murakami. The method of drawing crease pattern of kamiya pattern and its variety by skeleton. *Science of Origami*, 6(1):22–30, 2017. (written in Japanese).